e. estimate the volume of each depressed feature by determining its heat loss rate relative to the mean temperature of the item, considering also the materials composition of the item.

REMARKS

Claims 1-24 are currently pending in the application. By this amendment, claims 1, 3-14, and 17-24 are amended for the Examiner's consideration. Attached hereto is a separate sheet entitled "Clean Copy of Pending Claims, As Amended" showing a clean copy of the claims pending in the application, as amended. Also attached hereto is a separate sheet entitled "Clean Version of Changes to Specification" showing the clean copy of replacement paragraph(s) to the specification.

The Examiner's indication that claims 14-17 contain allowable subject matter is acknowledged with appreciation. This amendment places these claims in condition for allowance.

Please note that a new Power of Attorney is herewith submitted by the applicant.

The Examiner's objection to the drawings is noted, and corrected drawings will be provided in due course. As to Figure 14, the line is part of a graph.

The abstract has been amended in accordance with the Examiner's requirement.

The list of references following the abstract included a reference to a provisional application of the same title, to which priority is claimed. The application is amended to move that reference from the end of the application to the first line after the title in accordance with 35 U.S.C. §119(e)(1) and 37 C.F.R. §1.78(a)(5)(iii), and

without fee in view of 37 C.F.R. §1.78(a)(4)(ii)(A). It is noted that the present non-provisional application was filed before November 29, 2000.

The references included after the abstract are being submitted in a suitable Information Disclosure Statement along with this amendment, and are therefore deleted from the application.

The Examiner has objected to certain informalities in the claims, which are corrected by this amendment.

The Examiner has rejected claims 3, 4, 6, 7, 14, 17, 23 and 24 under 35 U.S.C. §112, second paragraph because of certain reference inconsistencies and other antecedent basis errors, which are corrected by this amendment. In claim 17 the Examiner notes that the term "enhances" is relative, and the Examiner's suggested change has been incorporated into this amendment.

The Examiner has rejected claims 5-12 under 35 U.S.C. §102(a) as being anticipated by U.S. Patent No. 5,857,202 to Demoly et al. ("Demoly"). However, Demoly differs from the present invention in a number of relevant particulars. Demoly uses only visual imaging and visible light to inspect projectiles. Also, he extracts digital values and characteristics from each image feature of interest, and he compares the resulting listing of data to similar digital data from other projectiles in a database. Note that at col 4, line 45 his disclosure provides "The alphanumeric values for the striations are extracted by data processing to obtain, from the images of striations taken by the camera, the equations of the straight lines representing these scratches." His feature selection is a manual process. He doesn't automatically locate features, as in the present invention. Note also that at col 5, line 56 Demoly says "The operator... manually enters the other data such as the caliber, weapon family, type of weapon, etc." His system does not automatically determine that information from the imagery. Furthermore, he states it is not possible to distinguish between dark and light striations. He emphasizes the effect of glancing light on the appearance of the

striations; he does not describe or suggest the use of passive infrared imaging to avoid the problem.

In particular, Demoly does not use an infrared camera to avoid illumination artifacts, or compare infrared and visual images to eliminate illumination artifacts prior to matching, or obtain depth information from the marks by using a radiometric infrared camera, or separate features by depth (volume). His invention is exclusively for comparing projectiles, whereas the present invention is for comparing tool marks on any item.

As to claim 5, the sequence of the present invention corresponds to differing focus in a systematic way, whereas Demoly produces no such sequence. The tag of the present invention includes the focus position for each image, whereas Demoy has no such focus reference in his database. Therefore, he does not have a tagged sequence as defined in the present invention. Furthermore, the images in the present invention are infrared whereas his are normal visual images. Claim 5 has been amended to specify this feature. Demoly compares characteristics of the striations (col 4 line 60) extracted and encoded. The present invention compare infrared image sequences. His correlation involves only 2-D pixel by pixel matching. The present invention uses depth information contained in the sequence of images, and so is able to match the depth of features, not just the 2D extent. Both the present invention and Demoly suggest that a human examiner make the final determination, however, in the present invention the examiner is looking at sequences of infrared images. In Demoly the examiner is looking at digital scores and one visual image per item.

As to claim 6, Demoly's processing involves computing a correlation function in 2D which involves the position of striation and other marks. Processing in the present invention involves considering sequences of IR images, matching each image in a sequence (corresponding to different depth features) to each image in database sequences. Therefore processing involves comparing sequences of 3D information.

As to claim 7, Demoly does not tag with depth of features and does not use sequences. Tagging in the present invention refers to sequencing in accordance with the invention. Demoly does not use sequences, and therefore does not tag as defined in the present invention. The present invention uses a different apparatus, including the infrared camera and lens and the focusing adjustment. Therefore, each image is tagged with the focus information but, in claim 7, an examiner is permitted to consider variations in those elements. That is done by showing the tag information (including depth) and letting the examiner make the decision whether to permit matching based upon images which represent different depths of features.

As to claim 8, the present invention allows for an automated consideration of those variables. Demoly doesn't image or tag or collect depth information and therefore does not "tag" features by depth.

The Examiner has rejected claims 1-4, 13 and 19 under 35 U.S.C. §103(a) as being unpatentable over Demoly and U.S. Patent No. 4,884,696 to Peleg, further in view of U.S. Patent No. 5,761,336 to Xu et al. ("Xu"). The differences between Demoly and the present invention has been discussed above. As to Peleg, he doesn't use passive infrared sensors. All his sensors are based on transmitted or reflected radiation which he creates from active sources. Use of passive sensors in the present invention, in particular the use of passive infrared focal plane arrays of detectors, to determine the 3D geometry of striations and other physical marks, is the key element of the present invention and is not found in Peleg. Also, Peleg does not address the problem of illumination-created artifacts in inspection of metallic items. In his lists of problems with current inspection technologies, at columns 2 and 3, he makes no reference to that topic, which is key to the effectiveness of use of infrared imaging in present invention. Peleg's reference, in col 3, line 52-64 as cited by the examiner, to "Infra Red" is to a type of "reflected radiation". He consistently refers to infrared only in terms of an infrared or ultraviolet light which he shines on the item in question.

When Peleg mentions "internal energy dissipation" in column 4, line 36, which the examiner equates to heating, he obtains an overall measurement of the item. In contrast to the present invention, he does not analyze 3D features, such as striations, to determine their differences from other portions of the item. His inspection and classification of natural or manmade products relies on visual inspection. He does not use different focal lengths to separately create each image in a sequence. He mentions in column 19, line 63, that machines are capable of processing "512x512 or 1024x1024 pixels image", and the examiner notes that this equates to multi-resolution. This observation is beside the point. Peleg's system is essentially a conveyor-sorter, which deals with gross characteristics of items. It does not deal with microscopic features of what are essentially identical items (shells). He would sort all similar shells (e.g. 38 caliber brass) into the same bin. Also, Peleg does not match microscopic patterns to a database of similar patterns to determine that they were produced by the same tool. He only matches gross parameters to sort items and classify them. Any inspection of defects is done by human inspectors in his system.

As to claim 1, in contrast to the present invention, Demoly does not produce a tagged sequence in which the tag relates to the focal length and the sequence is of the same item, with the focal length changing. The examiner is not correct in saying that Peleg is capable of classifying ballistic items based on data gathered from sequences of infrared images. As stated in the summary above, Peleg doesn't use passive infrared cameras, he doesn't collect sequences as the focus is varied to image different depths, and he doesn't analyze striations or other tool marks. Claim 1 is for characterization of a ballistic item; Peleg might be used to classify an item {determine that it is a 38 shell) but could not determine that it had been used in the same weapon as another shell. As stated above, the fact that Peleg recognizes that machines can process images of different array sizes is not equivalent to systematic use of stepped-focus images as provided in the present invention.

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Regarding the Xu prior art, his invention is a method for adjusting a microscope to best detect defects. He realizes that increasing resolution is not always better, since increased resolution imaging of a complex item produces more false detections of defects that don't really exist. He detects defects, particularly in semiconductors, by comparison to a sample which is manually selected. Defects in the sample are manually determined. His invention is a method for manipulating a microscope to best reproduce the defect detection done manually on the sample. He first adjusts the illumination level to achieve the highest ratio of defects to false defects. Here is where he should use infrared imagers to eliminate the false defects. The fact that he does not is evidence that the use of passive infrared imagers in total darkness to detect and match tool marks (defects) is a novel approach he did not consider. Thus Xu teaches away from the present invention.

Xu then adjusts the aperture to produce the highest defect detection rate. His method is primarily needed because higher resolution imaging produces higher numbers of false defect detections. He mentions texture as "graininess", and selects an aperture based on graininess of the overall target. To Xu, high graininess causes "noisy, uneven, color varied, or complex images" (col 6, lines 7-9) while low graininess causes "relatively simple, smooth, 'clean' images" In the present invention, texture changes occur across the item and produce the features used for processing. In Xu, texture equates to noise. Every claim involves use of a light source. He doesn't deal at all with the matter of tool marks, or identifying what tool caused any defects seen.

The Examiner correctly notes that neither Demoly nor Peleg use multiple images representing a sequence of feature depths. However, reliance upon Xu is misplaced, since Xu does not talk about the "context of surrounding features". Even if he did, reducing false defect detection by adjusting the microscope aperture does not equate to matching sequences to sequences, or matching infrared to visual images,

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which are two ways the present invention reduces artifacts. The Examiner fails to acknowledge the most important novelty of the present invention, namely the use of infrared images. There is a difference, not recognized in the comments, between actively shining an infrared light on something to produce a reflection imaged with a visible camera, as compared to passively imaging an object using a camera sensitive in the thermal infrared spectrum. Active IR illumination produces glare and tends to flatten out surface features. Passive IR collection obtains feature details in total darkness - with no glare or other lighting artifacts. The claims have been amended to clarify this point.

As to claim 2, Demoly does not provide for a photomontage comprised of different sections of the image sequence, where each section is selected from the image in the sequence which shows it in sharpest focus. The Examiner states that producing a photomontage is "a mere display choice of the user interface designer". However, Demoly specifies a scrolling list of all displays at window 59; he does not anywhere compose a photomontage from an image sequence.

As to claim 3, Demoly calculates scores for his criteria (including size) and then matches the digital scores. That is not the same as creating a new image sequence in which each image contains only those features which are of a selected size or greater. The Examiner mentions that size restrictions are obvious to avoid the problem addressed by Xu. However, the problem addressed by Xu deals with higher image resolution creating more false defects due to illumination effects; that is not the issue here. The present invention matches tool marks and disregards anything smaller than those marks. There aren't any illumination problems – that is the whole point of using passive infrared imaging.

As to claim 4, Demoly requires manual determination of all these items. The present invention, as per Figure 14, determines many of them automatically from the image sequences. Claim 4 is dependent on the prior claims and the major differences

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with Demoly are in those. Regarding claim 13, Peleg does not mention heating. He mentions the measurement of "internal energy dissipation" in the context of frequency response or vibration damping. Xu also does not mention heating or temperature variation. Demoly also does not mention heating the items. None of the examiner's references deal with heating or cooling an item as it is being imaged. None deal with the analysis of Figure 14. Varying the temperature is not done to measure the temperature changes of the target item; rather, it is done to enhance the visualization, or contrast, between tool marks and the rest of the item. It is a key element of the present invention and nothing similar occurs in any of the references cited by the examiner. Further, it is not obvious to tag images automatically with the temperature and then produce the chart of Figure 14. Since it is not obvious to heat or cool the items and use a passive infrared camera, it would not be obvious to automatically tag the resulting images with temperature measurements from the radiometric infrared camera.

As to claim 19, Peleg does not include an infrared camera; rather, he includes "Visual, IR, or UV light filters" in his Figure 12. None of the prior art referenced by the examiner performs automatic image comparison based upon sequences of images obtained in total darkness using infrared cameras. None of the prior art systems includes an infrared camera.

The Examiner has rejected claims 18, 20 and 21 under 35 U.S.C. §103(a) as being unpatentable over Demoly and Xu as applied to claim 1, and further in view of U.S. Patent No. 5,483,387 to Bauhahn et al. ("Bauhahn"). However, contrary to the Examiner's assertion, Peleg does not teach using infrared imaging to identify objects, nor to identify features on an object. See the above discussion concerning the significance of passive infrared imaging. Further, the cited wording in the Bauhahn reference doesn't appear anywhere in column 1 or anywhere else. Bauhahn's patent deals with separating emissivity and temperature effects in infrared imaging through a

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mechanism using deep lamellar structures. The examiner's citation of column 7, lines 5-10 where he "teaches identifying the presence of spectrally active chemical agents" is not a correct quote. The correct quote is that he "could identify the presence of spectrally active vapors and gases". For the purposes of considering the present invention, "gases and vapors" are not the same as "residue on a ballistic item". Demoly makes no mention of possible residue in the reference cited by the Examiner's (Fig 5, element 59), and there is no support in the reference to the suggestion that there is "obviously desire to obtain chemical agent information."

The Examiner has rejected claim 22 under 35 U.S.C. §103(a) as being unpatentable over Demoly as applied to claim 1, and further in view of U.S. Patent No. 5,659,626 to Ort et al. ("Ort"). Ort is a fingerprint matcher; all his features (minutiae) derive from visual images of fingerprint ridges, meaning they are all end points, branch points, or islands (very short ridges). The Examiner's references don't match the present invention. Examiner says Ort "computes centroids location for each feature including striations, gouges, breach face marks, and firing pin indentions". Ort doesn't talk about any of those. The referenced Ort column 24, 33-36 and column 28 lines 1-3 don't contain the word "centroid". There is no description of centroids anywhere in Ort, and therefore no suggestion of computing distances between pairs of centroids. Again, the present invention uses passive infrared images, and claim 22 has been amended to make this clear.

The Examiner has rejected claim 24 under 35 U.S.C. §103(a) as being unpatentable over Peleg as applied to claim 1, and further in view of U.S. Patent No. 4,983,836 to Matoba et al. ("Mataoba"). Claim 24 includes an infrared camera, which is not in Peleg. As discussed above, contrary to the Examiner's assertion, determining the energy dissipation characteristics of an overall item is not the same thing as determining the rate of cooling of specific features relative to the overall item. Also, as stated earlier, Peleg does not use passive infrared imaging; rather Peleg

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uses an infrared filter on a visual camera, which is a very different instrument. Furthermore, the Examiner's conclusions about the applicability of Matoba and Forester and Peleg are misplaced. Matoba heats the inside of a pipe and then uses an IR camera from the outside to find thinned portions of the pipe wall. He relies upon the reduced mass in the thinned area to transmit more of the heat to the outside wall. He is using the IR camera to visualize the transmission of heat, which is greater when the pipe walls have thinned. If he doesn't heat up the pipe, he has no useful image. In the present invention, the IR camera is used to image the emissivity differences associated with scratches and other tool marks. Heat is used only to enhance the differences, and the entire item is heated and then imaged it as it cools. Matoba needs to image with the heat constantly on. His technique would not work for ballistics identification; heating one side of a bullet would not produce an identifying image taken from the other side.

Forester's method applies to detecting and identifying a second substance placed in a sample of a different substance. It does not apply to identifying changes to the texture of a single substance. Forester does not include any discussion about texture or emissivity changes, or about how these affect infrared images. Matoba's method for estimating the area and depth of pipe thinning cannot be used to determine tool mark depth. Matoba relies upon the pipe wall being eroded away; not its being compressed. Given that a tool compressed the face of an item, the compressed area would still have the same thermal mass and therefore would not show a thermal difference. However, it would show an emissivity difference on the face impacted by the tool. This is true whether or not the item is heated. Heating provides more datapoints for computing the volume of indentations. The item classification features of Forester do not apply to characterizing tool marks on ballistic items or any other items. They do not apply to identifying a ballistic item by matching striations to a database. The infrared depth calculation system of Matoba does not apply to tool

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marks; it only determines thermal image changes associated with varying the amount of material between a heat source and an infrared imager. It does not provide any evidence, much less any measurement, of tool marks. The Peleg system makes no use or reference to infrared imaging. His only mention of IR is of an infrared filter on his visual camera to keep out stray infrared radiation.

In view of the foregoing, it is requested that the application be reconsidered, that claims 1-24 be allowed, and that the application be passed to issue.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at 703-787-9400 (fax: 703-787-7557; email: clyde@wcc-ip.com) to discuss any other changes deemed necessary in a telephonic or personal interview.

Please charge any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 50-2041.

Respectfully submitted,

Clyde R Christofferson
Reg. No. 34,138

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PATENT TRADEMARK OFFICE

CLEAN COPY OF PENDING CLAIMS, AS AMENDED

The following are the complete set of claims pending in the application, as amended:

1. (Amended) Method for characterizing a ballistic item including the steps:

a. Produce a sequence of digitized passive infrared images of the item at different focus points such that the deepest to the highest features are each in sharp focus in at least one image,

b. tag each image with the ID of the item,

c. tag each image with specifics of the imaging set-up including the focus position, and size of digitized image array

d. store the tagged image sequence in a database

2. Method of claim 1 with the additional step:

e. produce a photomontage from the tagged image sequence in which each section of the montage image is the corresponding section of the image from the tagged sequence in which that section is in sharpest focus

3. (Amended) Method of claim 1 or 2 with the additional step of replacing each tagged image in the sequence with a tagged extracted feature image containing only features at least a specified size extracted from the tagged image

4. (Amended) Method of claims 1, 2, or 3, further comprising steps:

adding to each tag weapon-specific ancillary information including calibre, type of ammunition, direction of twist, number of lands, serial number, and

adding to each tag incident-specific information including type of crime committed, location where item was found, associated names, method of crime.

5. (Amended) Method for identification of a ballistic item including the steps:

a. characterize the unknown ballistic item by producing a tagged image sequence

b. compare the image sequence with those contained in a database

c. determine those sequences in which one or more images are similar to the unknown tagged image sequence

d. display the similar pair(s) of images to a ballistics examiner who reviews the display and rules that the unknown ballistic item is a match to an item in the database if the similar pair(s) of images are sufficiently alike.

6. (Amended) Method of Claim 5, wherein step d is performed automatically by further image processing

7. (Amended) Method of Claims 5 or 6, further comprising the steps:

comparing the weapon-specific and incident-specific tagging information of the similar image pair(s);

displaying the similarities and dissimilarities in the tagging information along with the images for further consideration by a ballistics examiner who reviews the display and rules that the unknown ballistic item is a match to an item in the database if the tagging information as well as the similar pair(s) of images are sufficiently alike.

8. (Amended) Method of Claim 7, wherein the reviewing by the ballistics examiner is performed automatically by further image processing.

9. (Amended) Method for identification of a ballistic item including the steps:

a. characterize the unknown ballistic item by producing from passive infrared images a tagged extracted feature sequence

b. compare the extracted feature sequence with those contained in a database

c. determine those sequences in which one or more extracted features are similar to the unknown extracted feature sequence

d. display the similar pairs of extracted features to a ballistics examiner who reviews the display and rules that the unknown ballistic item is a match to an item in the database if the similar pair(s) of extracted features are sufficiently alike.

10. (Amended) Method of Claim 9, wherein the reviewing by the ballistics examiner is performed automatically by further image processing

11. (Amended) Method of Claims 9 or 10, further comprising the steps:

comparing the weapon-specific and incident-specific tagging information of the similar extracted feature pair(s); and

comparing the similarities and dissimilarities in the tagging information along with the extracted features for further consideration by a ballistics examiner who reviews the display and rules that the unknown ballistic item is a match to an item in the database if the tagging information as well as the similar pair(s) of extracted features are sufficiently alike.

12. (Amended) Method of Claim 11, wherein said comparing step is performed automatically by further image processing.

13. (Amended) Method of Claim 1, further comprising the steps:

heating or cooling the ballistic item to vary its temperature;

producing an image sequence in which both focus and temperature are varied; and

tagging each image with the corresponding temperature.

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1 ~~14~~. (Amended) Method to identify illumination-induced artifacts in visible light photography of ballistic items including the steps:

a. Produce visible and IR image sequences of the same ballistic item;

b. extract features from each image in each sequence;

c. tag as a candidate illumination-induced artifact each feature in a visible image which does not have a corresponding IR feature; and

d. tag dark visible artifacts as possible shadows and light artifacts as possible glint.

15. Method of claim 14 in which spectral filters are used to tag certain artifacts as possible debris including oil, gunpowder, fingerprints.

16. Method for distinguishing lands and grooves in visible light photography of ballistic items including the steps:

a. produce visible and IR image sequence of the same ballistic item

b. extract features from each image in each sequence

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c. readjust the look-up table of gray scale allocation for the visible image such that the resulting image most closely matches that of the IR image

d. Display the resulting visible image which will have more consistent appearance of lands vs. grooves.

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4 ~~17.~~ (Amended) Method to differentiate manufacturing marks and weapons-related tool marks on shell casings including the steps:

a. adjust the focus on the IR camera such that the manufacturing marks are in focus;

b. adjust the temperature of the ballistic item such that the manufacturing marks are most distinct from the surrounding area; and

A3

c. threshold the resulting image to create a template of the manufacturing marks to be used for matching or for eliminating the marks from that image prior to further matching.

18. (Amended) Method to detect residue on a ballistic item, including the steps:

a. apply a sequence of spectral filters to the IR camera

b. for each filter, vary the focus to produce an image sequence of passive infrared images

c. extract features from each image in the sequence

d. compare the feature sets in images which have the same focus setting but different spectral filters

e. display those features which are filter-sensitive as possible residue

f. Annotate features with likely type of residue based upon the filter sensitivity.

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19. (Amended) Apparatus for characterizing a ballistic item including:

a. IR camera with lenses and focus control

b. Mechanism for varying the focus control to produce a sequence of images

c. Image digitizer and storage

d. Mechanism for tagging images with [anciliary] ancillary information

e. Feature extractor

f. Processor for characterizing the features

g. Processor for creating a montage

A3

h. Display

i. Mechanism for positioning the item within the camera field of view.

20. (Amended) The apparatus of claim 19 including also the elements:

j. device for heating the ballistic item

k device for measuring the temperature of the ballistic device

l. device for applying optical filters before the camera lens

m. mechanism for tagging the resulting images with temperature and filter data.

21. (Amended) Apparatus for identifying a ballistic item including the elements of 20 plus:

n. Database of characterized ballistic items

o. Database matching engine

p. Output or display mechanism

22. (Amended) Method for identifying a ballistic item including the steps

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~~a.~~ for each montaged infrared image derived from an unknown item database and a known item database produce a relative location map as follows:

b. compute the centroid location for each feature, including all striations, gouges, breech face marks, and firing pin indents, where each striation is considered a separate feature.

c. Compute the distances between each pair of centroids

d. Tag the distances with the type of feature represented at each end

e. Match the list of tagged distances with corresponding lists for the known item database.

A3

23. (Amended) Method for separating manufacturers marks from weapons marks in ballistic images, including the steps:

a. heating the ballistic item to enhance the manufacturers marks;

b. producing a passive infrared image of the ballistic item;

c. producing a template of the areas containing the enhanced manufacturers marks; and

d. extracting the template areas to form an image containing the manufacturers marks,

wherein the remaining image contains no manufacturers marks but contains weapons marks which did not overlay manufacturers marks.

24. (Amended) Method for estimating the volume of groves, indentations and striations in ballistic items including the steps:

a. heat the ballistic item to an elevated temperature

b. measure the mean temperature of the item using a radiometric infrared camera

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c. capture a sequence of passive infrared images as the item cools

d. capture for each image the mean temperature using the radiometric camera

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e. estimate the volume of each depressed feature by determining its heat loss rate relative to the mean temperature of the item, considering also the materials composition of the item.

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CLEAN VERSION OF CHANGES TO SPECIFICATION

The following paragraph is now inserted before page 1, line 1:

A4

This application for patent claims priority from U.S. Provisional Patent Application No. 60/087,512 filed June 10, 1998.

Marked up paragraph at page 1, lines 28 to page 2, line 6, where a tab indent is inserted, now reads:

A5

The shell casing receives marking from the firing pin hitting the primer, from the back pressure of the gas expansion forcing the casing against the breech face of the firing pin housing which may have marks or defects which transfer onto the primer and/or casing. These marks may be a result of manufacturing defects, or hand finishing done in high quality weapons. Breech face marks can be compared just as can firing pin marks, either by firing a test round or by examining the weapon when the weapon is available, or by comparing corresponding marks on two bullets or casings which are suspected of coming from the same weapon. If the same weapon is used to fire the same type ammunition at the same type target from the same distance, comparable patterns will be produced on the bullet and casing. If the ammunition is changed, the patterns will be somewhat different.

Marked up paragraph at page 2, lines 11-19, where a tab indent is inserted, now reads:

A6

Class characteristic marks vary with calibre, load, material used for the bullet or shot, bullet weight, its impact behavior, material used for the casing, and

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identification stamped into the bullet and casing. Intentional marks on ammunition include information stamped on the face of the bullet casing during molding of the shells. Some casings and bullets also have an indented ring or rings around the circumference called a canellure. These are smeared with grease or wax as sealer, making the bullet water-resistant and providing some lubrication as it is forced through the barrel. The canellures on the casing are imprinted within a quarter inch from the top after the bullet is inserted. This crimp acts to seal the round and hold the bullet in the casing. Canellures may contain imprint information unique to the manufacturer and perhaps to a particular crimping tool.

46

Paragraph at page 10, lines 15-16 now reads:

Image sequence focus montage - also referred to as a montage - combined sharp focus portions of multiple images in a sequence to make one or more composite images

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Paragraph at page 12, lines 6-14 now reads:

The individual characteristics of the ammunition and weapon include the particular surface condition and shape of the bore, the particular striations imposed on the bullet, and the particular markings imposed on the casing. These characteristics can also be determined using infrared images. Even when caseless Teflon bullets are used, active infrared imaging may exploit minute markings transferred to the bullet by the barrel and firing charge. A rotating IR probe, similar to endoscopic cameras in medical use, can produce a detailed image of a gun barrel, which can then be matched against casings and bullets which are suspected of having been fired from that gun. In some instances, this may be preferable to making test firings from the weapon;

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4.8

particularly if the weapon is considered unsafe, or if it is necessary to preserve the weapon in its present condition as to residue etc.

Paragraph at page 12, lines 28-30 now reads:

4.9

Heat conduction analyses can be performed by heating the ballistic item and imaging it while it cools. Estimates of the depth and volume of indentations, striations, and gouges can be made based on their cooling rates. The material composition of each area of the item must be considered.

Paragraph at page 13, lines ~~4-16~~ 2-14 mem now reads:

4.10

Current systems, such as DrugFire, compare an unknown ballistic item's image to all corresponding images in a database, producing a correlation value for each. Database images are then re-ordered based upon that correlation value, with the highest correlation ranked first. In controlled testing where the identities of all siblings are known, a measure of the accuracy and efficiency of the matching engine is the position of siblings in the re-ordering. The results shown below in the left column are taken from the DrugFire system manufactured by Mnemonics Systems Inc.. The right column shows the use of a different matching engine (FlashCorrelation® patented by the inventor) with the same visual image database as used by Mnemonics. 1157 shell casings from 229 weapons were used for the tests. The images were all taken with a conventional videomicroscope camera. MIKOS did not have the opportunity to collect its own images of the casings. Therefore, no infrared images were obtained or used for this comparison test. The purpose of this table is merely to show how ballistic matching systems are evaluated. In a smaller test, the use of infrared imagery produced significant additional improvement in

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position of siblings over the use of visual imagery, with nearly all siblings clustered at the very top of the ranking.

new
17-25
Paragraph at page 16, lines ~~19-27~~ now reads:

¶11

Selection of features to be characterized, and the characterization process, can be fully automated or manually assisted. Partitioning significantly reduces the search time required to look for matches, but requires knowledge about the variations which may occur in firings of a particular weapon. For example, changing the ammunition size or type used will change the markings imposed by the weapon. Therefore, in conducting a search against a database, to reduce the occurrence of false negative results, the criteria for including a database item as a candidate matching item must be considered relative to possible variations such as: whether the weapon has interchangeable barrels, whether it might be used with different sized ammunition, whether it might have been cleaned, whether it might have had heavy use between the database entry and the current characterization.

new
17-20
Paragraph at page 18, lines ~~19-22~~ now reads:

¶12

Images in the casing sides and bullet databases should be formed as composites of the multiple frames taken as the bullet or casing is rotated. The composite images can be oriented so as to align striations with the horizontal plane of the image. Due to spiraling of the lands and grooves, image segments must be composed to create an image of the resulting striation pattern from the various segments imaged.

22, line 26 – page 23, line 5 new
Paragraph at page ~~23~~, ~~lines 1-10~~, now reads:

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Figures 1a, 1b, and 1c are visible images of the primer areas of sibling casings. The image illustrate the effects of illumination variations and artifacts. In particular, the firing pin indentations in the centers lack any details, and each shows glint from the illumination. Each image is oriented based upon the breech face marks and the position of the firing pin indentation. 1a has the best detailed primer area. The illumination of 1b causes much of the breech face markings to be lost., and reverses the appearance of the feature at 10:00 from a white to a dark line inside a grey area. The firing pin indent also appears smaller than in a. In c, a slight variation in the illumination angle make the firing pin indentation appear to be raised up instead. Turning the image upside down makes it appear to be an indentation; however then the position of the indentation is incorrect. Depending on the match engine, these siblings may not be detected as matches based upon these visible images due to the illumination-induced variations.

A13

15-18 man

Paragraphs at page 23, lines ~~20-23~~ now reads:

Figure 6 is an infrared image of a shell casing at ambient temperature, with focus set for a distinctive tool mark.

Figure 7 is an infrared image of a shell casing at ambient temperature, with focus set for a distinctive tool mark in the primer area.

A14

24-25

Paragraph at page 23, lines ~~29-30~~ now reads:

Figure 11 a,b,c illustrates the removal of the manufacturers markings from the casing image prior to matching.

A15

Paragraph at page 24, lines 24-25 now reads:

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416

A controlled light source 110 is then turned on to illuminate the ballistic item and a video camera 116 is used to produce a sequence of visible images 120 by varying the focus mechanism 118.

Paragraph at page 24, line 26 ~~to page 25, line 4~~ new to page 24, line 30 now reads:

417

Each image is annotated with date and time, workstation #, item temperature, focus setting, and item reference number. The focus and image capture processes can be automated such that a succession of minute variations in focus is performed and an image taken at each step, or the focus and image capture can be manually controlled using an examiners workstation consisting of a display screen 22 and input controls 24 including any combination of keyboard, mouse, voice, or similar device. The workstation also contains highlighting device 90 for manually specifying areas of images or textual information of particular interest to the examiner. The highlighter can be any combination of touch screen, lightpen, graphics tablet, or similar device. The display has the ability to mosaic several infrared 20 and visible 120 images on a single screen.

Paragraph at page 25, ~~lines 5-9~~ lines 1-5 new now reads:

418

Text information is entered which identifies the ballistics item and related information such as case #, weapon type, ammunition type, location where found, etc. That information can be read from an evidence tag using a bar code reader 28 or input through the controls of the examiners workstation such as by keyboard. The text information can be displayed on the screen 22 along with the corresponding annotated image.

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Paragraph at page 26, lines ~~9-13~~ 5-9 mam now reads:

A19

The resulting montaged infrared and visible images, along with their characteristics and textual information are entered into a database of infrared characterizations 50 and enhanced visible characterizations 150 of unknown ballistic items. The enhanced visible characterization can then be used with current ballistic identification methods and apparatus, producing more accurate results due to the elimination of illumination-induced artifacts, and the detection of hidden features due to shadow.

Paragraph at page 27, lines ~~7-11~~ 3-7 mam now reads:

A20

Text information is entered which identifies the ballistics item and related information such as case #, weapon type, ammunition type, location where found, etc. That information can be read from an evidence tag using a bar code reader 28 or input through the controls of the examiners workstation such as by keyboard. The text information can be displayed on the screen 22 along with the corresponding annotated image.

Paragraph at page 27, lines ~~15-18~~ 11-14 mam now reads:

A21

The sequences of infrared images are processed to extract and characterize apparent features at 42 using any of various standard automated image processing techniques or by manual highlighting by the examiner. Characterization at a minimum includes the relative positions of features, their shape, their area and perimeter length, and variation in gray scale distribution within the feature

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Paragraphs at page 28, lines ~~6-19~~ now read:
3-16 mem

Database 60 will contain characterization of known or linked ballistic items. When an unknown item 10 is presented for identification, it is processed as detailed above to produce its characterization at 50. The resulting characteristics are used to select initial candidates from the database 60 based upon text, image, and feature characteristics which are relatively immune to error or variation. For example, the calibre of ammunition. In matching shell casings, if the unknown firing pin indentation is centered, only database entries with centered firing pins are considered as potential candidates. The presence or breech face markings, ejector or extractor marks may also be considered relatively immune to error or variation.

A22

The initial candidate matches are then further processed using the text matching engine 70 which might provide for example the date of manufacture of the weapon, meaning that all ballistic items collected prior to that date need not be considered as matches. Other information is compared and scored as to similarity, such as information about the type of crime associated with the ballistics item, the locale where the item was collected, the presence of other similar items at the same collection, etc. The similarity score will generally not exclude candidates from further consideration, but may influence their rank ordering in presentation to a ballistics examiner for consideration below.

17-25 mem
Paragraphs at page 28, lines ~~20-28~~ now read:

A23

Remaining candidate matches are then further processed using the feature matching engine 72 which first compares summary characteristics such as the number and type of features, and then compares the details of each feature of the unknown and candidate items. Various metrics or scoring techniques can be defined to

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calculate a goodness of match based upon the feature characteristics. Fingerprint matching and face matching technique are especially suitable, with Prokoski et al. U.S. Patent No. 5,163,094 as an example. Candidates which do not correlate sufficiently with the unknown item are not longer considered.

Remaining candidate matches are then further processed by correlating the montaged images using an image processing technique such as Prokoski U.S. Patent No. 6,173,068 to produce an image correlation value. Other image processing comparison techniques may be used.

The paragraphs at page ~~37~~ 36, lines 1-20 have now been deleted.

The abstract now reads:

Systematic use of infrared imaging characterizes marks made on items and identifies the particular marking tool with better accuracy than use of visual imaging. Infrared imaging performed in total darkness eliminates shadows, glint, and other lighting variations and artifacts associated with visible imaging. Although normally used to obtain temperature measurements, details in IR imagery result from emissivity variations as well as thermal variations. Disturbing an item's surface texture creates an emissivity difference producing local changes in the infrared image. Identification is most accurate when IR images of unknown marks are compared to IR images of marks made by known tools. However, infrared analysis offers improvements even when only visual reference images are available. Comparing simultaneous infrared and visual images of an unknown item, such as bullet or shell casing, can detect illumination-induced artifacts in the visual image prior to searching the visual database, thereby reducing potential erroneous matches.